Ohio Agricultural Experiment Station

CIRCULAR NO. 63.

WOOSTER, OHIO, NOVEMBER 15, 1906.

THE GRAPEBERRY WORM.

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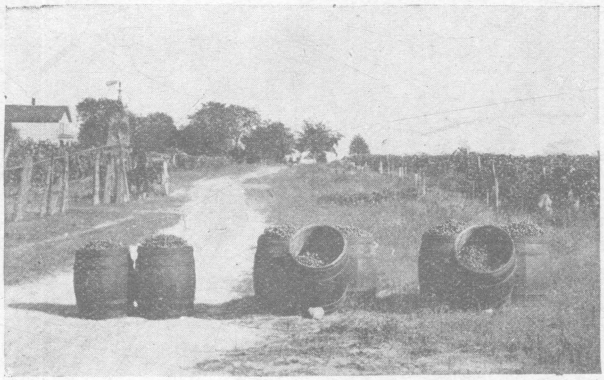
During the past two or three years the grapeberry worm, *Polychrosis viteana*, has done more injury to the Ohio grape crop than all other pests combined. The damage seems to be quite general wherever grapes are extensively raised in the state. The damage ranges from a small percent in some vineyards to one-fourth or one-half the crop in a greater number and again in an occasional instance the damage is so great that the crop is left unharvested. Over Kelley's Island, over North, Middle and South Bass Islands, around Danbury and along the shore of Lake Erie east and west of Cleveland, the loss for the season just closed has averaged one-third of the crop or more.



c *b* *a*

Harvest from experimental plots on North Bass Island. In each lot of barrels is the yield from two rows 240 feet long.

a: Hand sprayed with Disparene, 413 lbs.
b: Hand sprayed with Paris green, 402 lbs.
c: Double machine sprayed with Disparene, 316½ lbs.

LIFE HISTORY OF THE INSECT.

The purplish-brown moth is of small size, measuring less than one-half inch across its outspread wings. In northern Ohio the first brood of moths does not appear until sometime in June. On June 4th, no moths could be found. However, they must have appeared about this date for larvæ in abundance, some of them nearly half grown, could be found June 25th. A few moths, late stragglers of the first brood, could be found on the same date. No

moths could be found July 12th. At the date of our next visit to the vineyards on the Islands, August 15th, all stages of the insect, egg, larva, pupa and adult could be found, but whether these moths belonged to the second or third brood we do not know. Professor Slingerland of the Cornell Station says there are three broods in New York vineyards, the moths of the first coming about the first of June, of the second about the middle of July, and of the third about the middle of August.

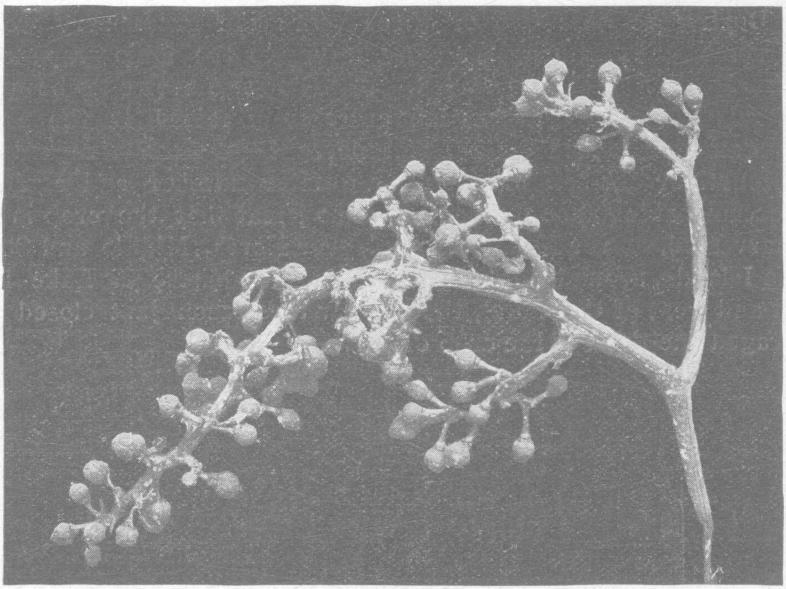


FIG. 1—A young cluster attacked by first brood of larvæ. Notice webbing together of berries in center of cluster.

The eggs are minute, translucent, iridescent specks found on the skins of the grapes in midsummer and supposed to be found on the stems of the clusters in case of the first brood. They sometimes so nearly resemble small films or spots of dried Bordeaux mixture that it is often necessary to examine them with a magnifying lens to determine their true nature. When the young caterpillars of the first brood issue from the eggs they commence feeding among the grape blossoms, webbing the flowers together and devouring the newly set fruit (Fig. 1). When the eggs of the late broods, which are laid on the skins of the grapes, hatch, the young larvæ burrow through the skin into the pulp, usually at the spots where they issued, though they occasionally migrate a short distance from the site of hatching before they penetrate the skin, or at least this seems to be the case. The grapes will have attained less than half their mature size before the small caterpillars burrow through

the skins and feed on the inside pulp. The point of entrance into the grape is surrounded by a patch of reddened skin. Some young worms of the first brood were observed feeding outside among the young grapes June 26th, but all had entered into the pulp before July 12th. The opening made through the skin furnishes a means of ingress for the spores of rots and fungous diseases and at a later time these wormy grapes crack open and decay (Fig. 2). The caterpillars migrate to other grapes as soon as their original food supply becomes too much decayed to be healthful for them. They invariably perish if compelled to remain in a mass of fermenting grapes without the possibility of reaching fresh food. Sometimes a single berry remains fresh and undecayed sufficiently long to mature a worm, but more often two or three are entered, and if worms are numerous by harvest time, many of the grapes upon a cluster are merely empty skins, others are partially decayed and of a mushy consistency, while others are freshly entered. Large clusters, consisting of 80 to 100 berries, will sometimes have every berry ruined.

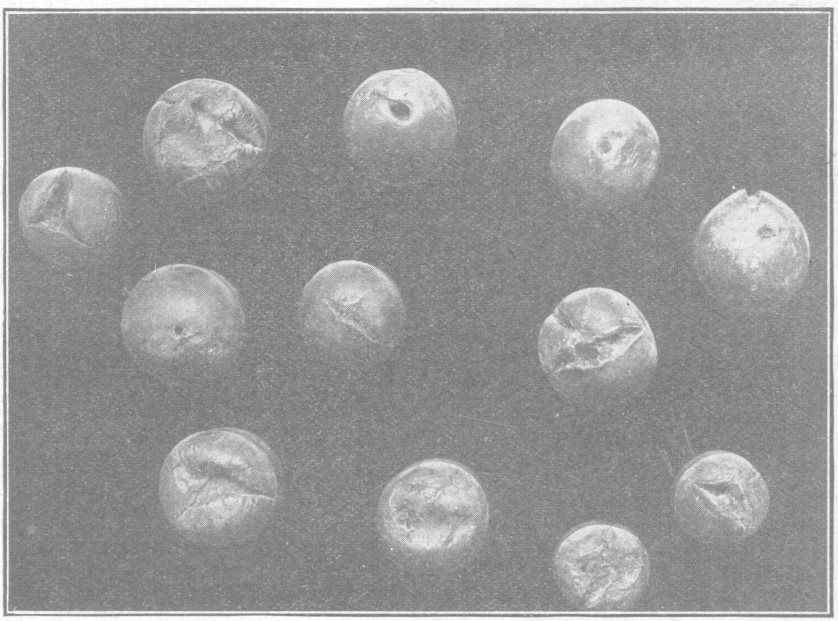


FIG. 2—Grape berries injured by larvæ and subsequent attacks of fungi.

When the caterpillars of the summer brood are grown, they cut small, rounded flaps in the leaves, which are folded back and fastened to the uncut side (Figs. 3 and 4) thus forming a little pocket or tube within which the caterpillar spins over itself a thin, whitish cocoon. In a few days it changes to a light greenish-brown pupa and remains in this chrysalis state for about

two weeks, when it emerges as a moth. The worms of the fall brood hibernate over winter in similar laps or folds on the fallen and decaying leaves. No cocoons could be found by the 16th of October on leaves still on the vines and, since many wormy grapes had already fallen, carrying some of the worms with them, it seems probable that many of the worms, perhaps most of them, fall to the ground with the grapes and then seek the fallen and partially anchored leaves for winter shelter, rather than trust themselves to the dry and loose leaves clinging on the vines which are soon to become the sport of the winds. Partially decayed leaves with numerous cocoons on them were received from Kelley's Island, October 22d. It seems probable that dried bits of grass and similar trash as well as fallen leaves are utilized for cocoon-making around the sodded borders of vineyards.

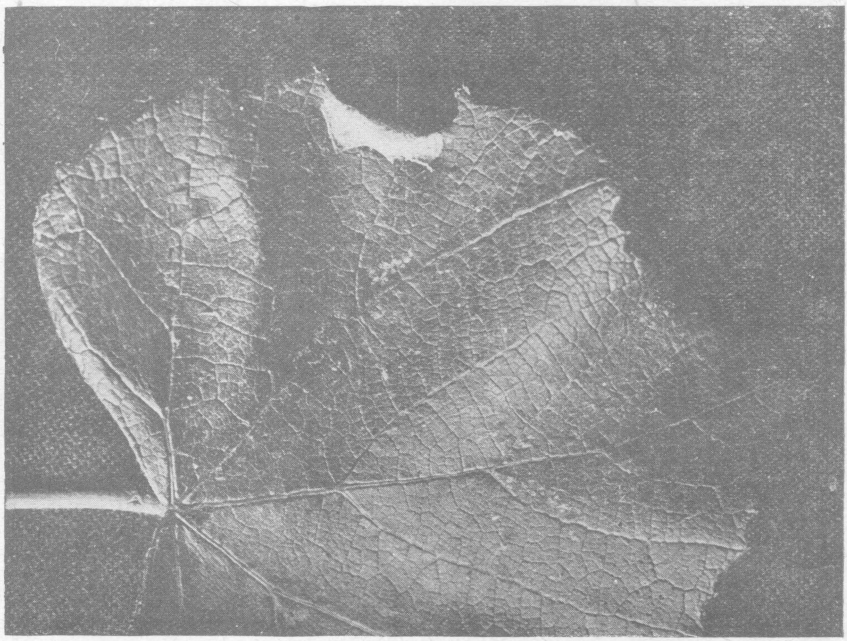


FIG. 3—The usual position of the cocoon. Twice enlarged.

REMEDIES.

FIRE.

Experience has shown that remedial measures are most effective when they are directed against the earliest or spring brood of this insect. The first brood must be practically annihilated so as to insure the smallness of subsequent ones. These measures may commence the preceding fall. As soon as possible after the worms

have gone into winter quarters, level all weeds and grass around the borders of the vineyard for several yards out with a mowing machine. Set on fire when the border trash is dry enough to burn. If necessary, spray this border with crude oil so as to make certain a hot and rapid flame. Cocoons, even when protected by a thin coat of dirt, would, in all likelihood, be consumed if slightly permeated with oil. Collecting the decaying leaves on the ground into piles, spraying with oil and burning might be of some use if done the last week in October or the first week in November, but the cocoons soon fall away from the leaves and, unless burned early, it is unlikely that such a measure would prove very successful. However, the plan is deserving of thorough trial over a few acres to test its efficiency.

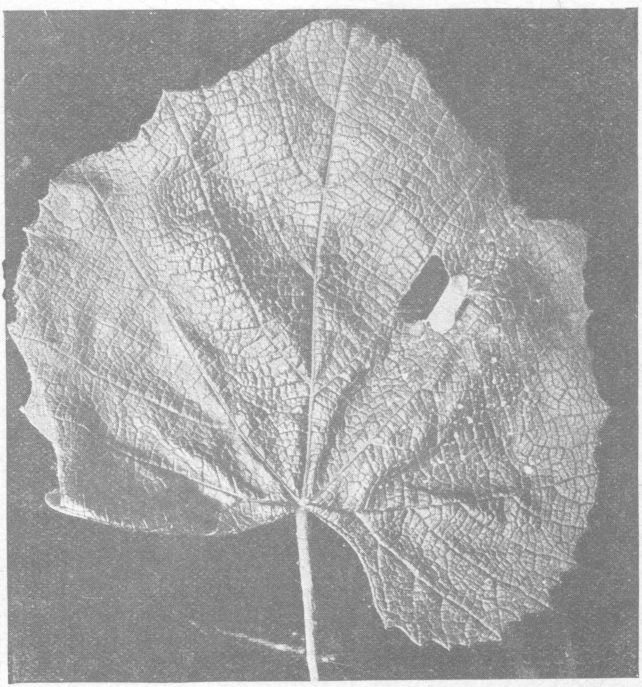


FIG. 4—Cocoons sometimes found thus. Natural size.

PLOWING.

It seems certain that nearly all the good results obtainable by burning can be secured equally well or better by plowing. Occasionally a border is of such character that plowing it up is impossible, while burning over it is not inconvenient. But where it is possible to plow we recommend this remedy rather than burning.

We cannot say whether fall plowing or spring plowing in the vineyard is best. Probably there is not much difference. Apparently, if the insect is allowed to follow nature's promptings, it spends the winter on the surface of the ground with only a very thin covering of earth over it or none at all. We do not know whether turning the cocoons under several inches of earth and keeping them buried for several months is necessarily fatal or not. Possibly some of them are brought to the surface again by spring cultivation just in good time to allow the escape of the moths. It would seem that not many could survive in this manner, but possibly a few, which are altogether too many, would do so If the plowing was deferred till spring and was done at a date late enough to make cultivation unnecessary until after the time for the appearance of the spring brood of moths, it would seem that they would be almost wholly destroyed. That plowing is a very efficient method of reducing their numbers is proved by the fact that the outer rows of vineyards next to the unplowed borders are always worst infested, especially in the spring before the moths have had a chance to scatter.

SPRAYING APPARATUS.

No method of combat against the Grape-berry worm is sufficient when used singly, but we must resort to a combination of several remedies. We think the most important measure of all is spraying with poison. We have demonstrated the past season that the moth can be practically controlled by the right kind of spraying in combination with plowing and burning. However, the kind of spraying that is necessary to control this pest will prove a revelation to many vineyardists who have fancied that they were spraying thoroughly. Neither expense nor labor can be with-held in this process and all who hesitate long at either, may about as well throw up their hands and surrender before they begin. When the harvest is in, it will be found that the extra expense incurred has been repaid many fold by the increased yield.

There are but few pumps built on the traction principle that are equal to the requirements against this insect, however satisfactory they may be against fungous diseases. In the case of the worm it is necessary to use a large quantity of spray and it must be thrown with great force, especially after the vines are in full foliage. The pump should be capable of maintaining a steady pressure of 100 pounds or more. The only pattern of traction sprayer of which we know and can recommend to the vineyardist is that by which air is compressed by the motion of the machine and stored up in a suitable chamber, the liquid being expelled by

this stored pressure Each spraying spar should carry not less than three or four nozzles. If the vines are tied to high wires the spars should be lengthened and the number of nozzles increased, so as to make sure that both the lowest and the highest clusters are covered with spray.

Another outfit which would probably give good results, but at a much higher cost, would be a gasoline power pump, capable of supplying from four to six leads of hose. The hose would need to be directed by hand, hence it would require several men to operate a single outfit. The greatest advantage in directing the nozzles by hand lies in the possibility of certainly covering every cluster with spray. For the late applications, after the foliage has become dense, this kind of a machine would probably do better work than the traction machines, but it would be far more costly and we think hardly more thorough for the early sprayings. A pump of this capacity ought to thoroughly spray the insides of the two rows, between which the machine was being slowly driven without stopping. If two leads of hose were used on each row, one should be directed at and into the top of the row, the other at and into its lower half. If three leads were used on each row, the driving should be faster; one hose should be used for high spraying, another for low and the third should follow after the other two and complete their work, being specially directed to inside locations through openings in the vines and foliage. The leads of hose would need to be of different lengths to prevent the workmen from getting in each other's way. The shortest of the leads should not be shorter than twelve or fifteen feet.

Hand pumps can be used only in small vineyards. Only the most powerful of hand pumps should be considered—such as are able to supply two leads of hose and maintain a pressure of 80 to 100 pounds without severely taxing the man at the handle.

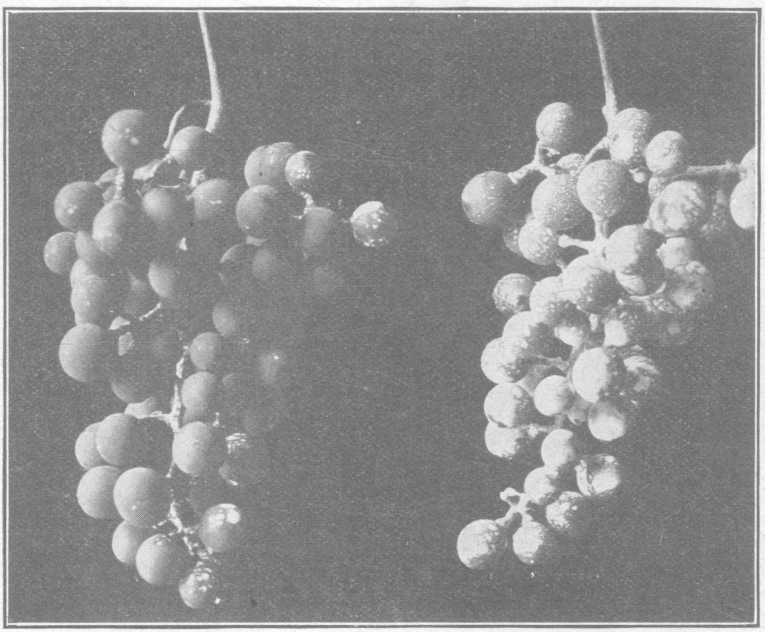
SPRAYING MATERIALS.

Almost any of the arsenical poisons will do, if a sufficient quantity is used. Disparene, used at the rate of 3 pounds in 50 gallons of Bordeaux mixture, gives better results than Paris green used at the rate of ⅓ pound in 50 gallons of Bordeaux. Some of the Paris green on the Ohio markets last season was adulterated and of very inferior quality. It became necessary to use at least ½ pound to 50 gallons to get satisfactory results and sometimes a greater quantity was required. White arsenic, in the form of arsenite of lime or arsenite of soda, seems to possess about the same merits as Paris green. In spraying grapes, always use the poisons in Bordeaux mixture. This will render the same application valuable against both insects and fungous diseases and insure against the burning of the foliage by the poisons.

The efficiency of all these sprays is practically doubled against the grape worm by adding a "sticker" to the mixture. Two pounds of laundry soap dissolved in water and added to each 50 gallons of spray will serve the purpose, but is needlessly expensive. A formula* for making a home-made soap with special sticking qualities is as follows:

Pulverized resin	25 lbs.
Concentrated lye	5 lbs.
Fish oil or any cheap animal oil except tallow	5 pints.
Water	25 gals.

Place the oil, resin, and 5 gallons of water in an iron kettle and heat until the resin is softened; add the lye after first dissolving it in water, and stir thoroughly; add the remaining 20 gallons of water and boil for two hours or until the mixture will unite with cold water, making a clear, amber-colored fluid. When boiling is complete add enough water to make 25 gallons of stock solution.



a *b*

FIG. 5—*a*: Cluster from vine sprayed with non-soapy mixture.
b: Cluster from vine sprayed with soapy mixture.
Notice difference in amount of spray adhering.

For use, pour 2 gallons of the stock solution into each 50 gallon tank of Bordeaux mixture and poison.

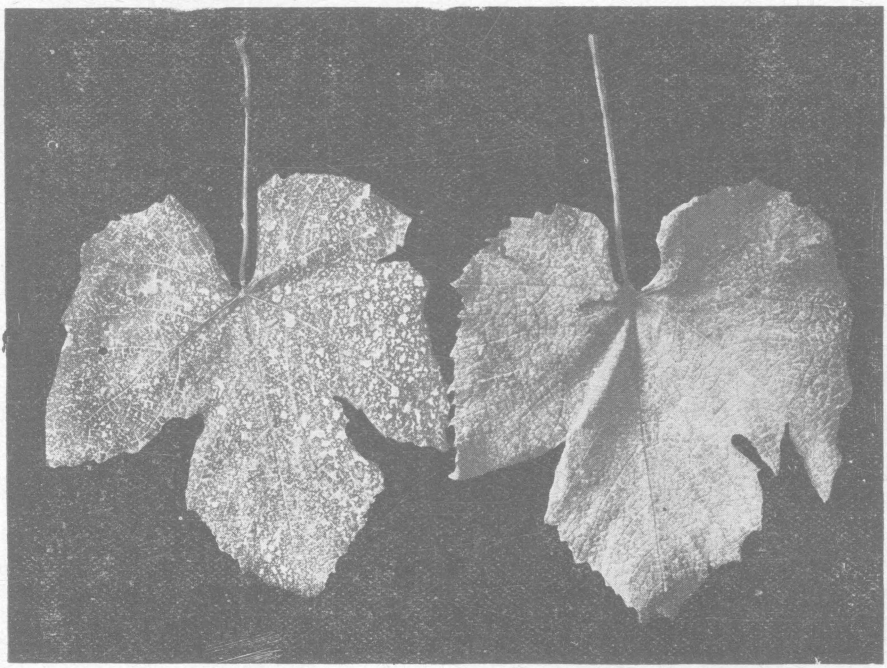
If, for purposes of convenience in storing and handling, a more concentrated product is desired, use the following formula† for 40 pounds of soap:

*Bull. 243, New York Exp. Station, Geneva, N. Y.

†Bulletin 257, New York Experiment Station, Geneva, N. Y.

Caustic soda	6 lbs.
Water	1½ gals.
Fish oil	22 lbs.

Dissolve the caustic soda in the water which has been warmed enough to readily effect the solution, and then gradually add the fish oil under constant and vigorous stirring. High temperatures are not required to effect the combination of the ingredients and the soap is quickly made.



a *b*

FIG. 6—*a*: Leaf from vine sprayed with non-soapy mixture.
b: Leaf from vine sprayed with soapy mixture.
Notice difference in eveness of spread of spray.

The soap spreads out as a thin film over the leaves and berries, each particle of soap on every bit of surface anchoring a particle of poison and of Bordeaux mixture, which adhere to it, thus leaving no spot anywhere that will safely pasture a worm or allow the germination of a fungous spore. Also the spray will adhere and protect more than twice as long as if the "sticker" were absent. Since the spray spreads more evenly and lasts so much longer with it in, we think it is economy to use the soap in order to reduce the quantity of spray needed, regardless of its effect upon the worms. The accompanying figures (see Figs. 5 and 6) show the fine distribution over the leaves of the spray as commonly applied, contrasted with that to which soap has been added.

Recent quotations on fish oil in barrel lots range from 35 cents to 38 cents per gallon and in 5 gallon cans from 40 cents to 42 cents per gallon with extra charge for container. Caustic soda will cost from $5.50 per 100 pounds to 10 cents per pound in 10 pound cans, the range in price depending on the amount of the order and the quality of the product. Vineyardists who are unable to obtain these materials in their local markets may procure them by corresponding with such houses as these: The Walding, Kinman & Martin Co., Toledo, O., Harshaw, Fuller and Goodwin, Electric Building, Cleveland, O., The M. A. Graham Drugstore, Sandusky, O.

Besides Paris green the following poisons may be used:

ARSENATE OF LEAD.

The Bowker Chemical Co., Boston, New York and Cincinnati, sell it under the trade name of Disparene. The Merrimac Chemical Co., Boston, sell Swift's arsenate of lead. "Target Brand" arsenate of lead is made by the American Horticultural Distributing Co., Martinsburg, West Virginia.

Arsenate of lead can be made according to the following formula:

Acetate of lead	11 oz.
Arsenate of soda	4 oz.
Water	50 gals.

Dissolve the acetate of lead in one-half gallon of water and the arsenate of soda in another one-half gallon. Pour the two solutions together into a tank containing 48 gallons of water. The white precipitate formed is arsenate of lead. It may be advantageous to use nearly double this strength against the grape-berry worm. Purchase chemicals from a first-class wholesale dealer and specify that the acetate of lead shall contain about 59 percent available lead oxide, and that the arsenate of soda shall not contain more than two or three percent of chloride. Or, the following formula may be used instead of the foregoing:

Nitrate of lead	10 oz.
Arsenate of soda	5 oz.
Water	50 gals.

Prepare in the same manner as preceding formula.

ARSENITE OF SODA.

White arsenic	2 lbs.
Sal-soda	8 lbs.
Water	2 gals.

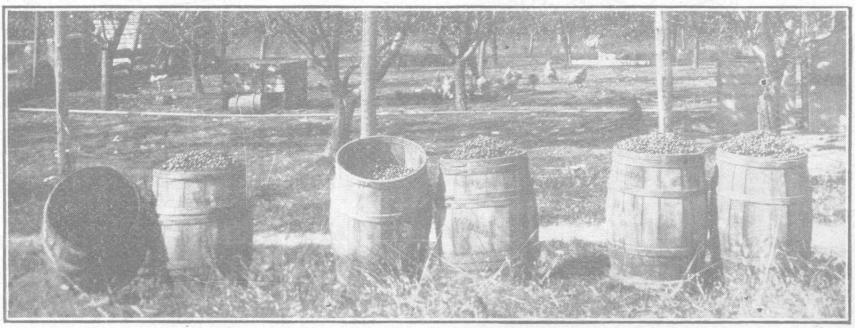
Boil until the arsenic is all dissolved, which will require 15 or 20 minutes. To prevent subsequent crystallization add enough water to replace that lost by evaporation. Put into an earthern vessel, label it poison, and keep as a stock solution. Never use the earthen

container for any other purpose. Use one quart to 50 gallons of Bordeaux mixture. This must never be used except in Bordeaux mixture or in combination with lime, otherwise the foliage will be severely scorched.

ARSENITE OF LIME.

White arsenic	1 lb.
Freshly slaked lime	2 lbs.
Water	3 gals.

Boil together for full 40 minutes after the boiling point is reached. Before diluting, strain through a sieve to remove the lumps. Use 5 pints of this mixture to 50 gallons of Bordeaux mixture.



a *b* *c*

Harvest at Kelley's Island. In each of the 3 lots of barrels is the yield from 2 rows, 186 feet long.
a: Paris green, single machine application, 229 lbs.
b: Paris green, double machine application, 348 lbs.
c: Arsenite of lime, double machine application, 368 lbs.

RESULTS OF SPRAYING.

We did considerable experimental work against the worm the past season in two different vineyards, one of them belonging to Mr. W. D. Smith on North Bass Island, the other to Mr. Henry Beatty on Kelley's Island. In both instances the applications were made with ordinary traction sprayers, very poor machines for such work. In order to demonstrate the difference between insufficient spraying and thorough work we made the applications in each vineyard by three different plans: (1) By single machine applications, that is by driving between the rows and finishing with the amount of spray thrown from each side of the machine, thus covering the inner half of each of the two rows. (2) By double machine applications, that is by driving between two rows as in (1) and at the end turning about and going back over the same track, thus applying twice as much liquid as with (1) and also putting it on from two opposite angles. (3) By hand applications. In making these, the pump was disconnected from the gearing, several feet of hose was attached and the pump was worked by hand, the nozzle also being directed by hand. It required brisk pumping to furnish enough pressure to produce the right kind of a spray by this method.

Mode of application	Insecticides used	NORTH BASS ISLAND					KELLEY'S ISLAND				
		Date of 1st spraying	Date of 2d spraying	Date of 3d spraying	Harvest in lbs. from 2 rows, 240 feet long	Rate of yield per acre in lbs.	Date of 1st spraying	Date of 2d spraying	Date of 3d spraying	Harvest in lbs. from 2 rows, 186 feet long	Rate of yield per acre in lbs.
Single machine	Paris green	June 4	June 21	July 12	128	1408	June 8	June 26	July 12	229	3321
Single machine	Disparene	"	"	"	205½	2261	"	"	"	345	5003
Double mach'e	Paris green	"	"	"	238½	2624	"	"	"	348	5046
" "	Disparene	"	"	"	316½	3482	"	"	"	333	4828½
" "	Arsenite soda						June 11	June 28	July 13	289½	4198
" "	Arsenite lime						"	"	"	368	5332
Hand.....	Paris green	June 2	June 20	July 11	402	4422	June 8	June 26	"	393½	5706
"	Disparene	"	"	"	413	4543	"	"	"	455	6598
"	Disparene with soap added								"	468	6782

See Figs. 7, 8, 9, 10, 11.

Under each of these three plans a plot was sprayed in each of the two vineyards with Disparene and a duplicate with Paris green. On Kelley's Island arsenite of lime and arsenite of soda were each applied to a plot by means of the double machine plan only. Also a plot which had been single machine sprayed with arsenite of soda three or four times after blooming, was sprayed by hand with Disparene on the 12th of July. 2 lbs. of laundry soap having been dissolved in warm water and added to 50 gallons of Bordeaux and Disparene as a "sticker". In all cases Disparene was used at the rate of 3 lbs. in 50 gallons of Bordeaux, and Paris green at the rate of ⅓ lb. in 50 gallons of spray. The dates of making these applications and the harvests therefrom are shown in the accompanying table. Since some of the plots consisted of as much as two or three acres and we had not time to get the total harvest, we chose two rows, as far as we were able to judge representing average conditions of yield in each plot, and from the harvest of these computed the rate of yield per acre.

Harvest at Kelley's Island. In each of the 2 lots of barrels is the yield from 2 rows, [illegible] feet long.
a, Arsenite of soda, double machine application, 289½ lbs.
b: Disparene, single machine application, 345 lbs.

It is seen from the table that Disparene gave a better harvest than Paris green in every case except on the double machine sprayed plots on Kelley's Island and here the difference was evidently due to other causes than the spraying, for several rows treated in different ways in this quarter of the vineyard gave comparatively light yields. The most remarkable result of all was with the plot to which the soapy spray was applied. This had been sprayed two or three times after blooming with arsenite of soda by the single machine method. The spray was observed to adhere to this plot for many weeks after the application and the final harvest proved at once the value of putting a "sticker" in the spray and of spraying as late as the middle of July. At the time of the grape harvest

hardly any fallen grapes could be found beneath the soaped vines, while the ground beneath rows on each side of the soaped plot was strewn with millions of fallen berries. With Catawba grapes at $60 per ton, the value of proper spraying is readily apprehended.

We tested August spraying without perceptible results.

COST OF SPRAYING.

According to the methods most commonly in vogue at this time, it costs from $3.75 to $5.00 to spray an acre of grapes during an entire season. This estimate includes the hire of the man and horse to run the sprayer, together with the cost of the Paris green and ingredients for making the Bordeaux mixture required for six to eight applications, this being the usual number. A number of light applications, rather than less frequent and more thorough ones are relied upon to bring about the desired results.

Harvest at Kelley's Island. In each of the 2 lots of barrels is the yield from 2 rows, 186 feet long.
a: Disparene, double machine application, 333 lbs.
b: Parisgreen, hand application, 393½ lbs.

As has been observed in the preceding table, the less frequent but more thorough sprayings gave better results. The cost of spraying an acre throughout the season in this manner varies from $5.50 to $7.50. By this method a machine is used throwing a somewhat stronger spray, and is driven twice between the rows instead of only once.

Spraying by hand with the ordinary traction sprayer, having the gearing detached and the power furnished by a man at the handle, is still more expensive. It is estimated that it would cost somewhere in the vicinity of $19.50 to spray an acre of grapes three times by this method. However, it should cost much less than this figure to do it by hand with a power pump as discussed on page 7.

RECOMMENDATIONS FOR SPRAYING.

We recommend, therefore, that the first spraying be made in early June before the blossoms open, and that 3 lbs. of Disparene, ½ lb. of Paris green or an equivalent amount of some other arsenical poison be added to each 50 gallons of Bordeaux mixture, and that some form of soap be added to the spray as a "sticker". Double spraying with the best types of traction-compressed air machines will probably be most satisfactory in large vineyards, while hand spraying may be equally good or better in small vineyards. It would be wise to allow an hour or more to intervene between putting on the first half and the second half of the double application.

The second spraying should be made as soon as the grapes are through blooming or a little before they have finished. This will be somewhere between the 10th and the 25th of June, according to season and location. Make the application in the same manner as the first.

Harvest at Kelley's Island. In each of the lots of barrels is the yield from 2 rows, 186 feet long.
a: Disparene with soap added, one hand treatment following machine application of arsenite of soda, 468 lbs.
b: Disparene, hand application, 455 lbs.

The third spraying should be made in early July and will be useful even as late as the 15th. It is especially important to add the soap to this application and if made with a traction machine, the pressure should be high so as to blow the foliage aside and throw a mist over the most sheltered clusters. We suspect a gasoline power pump and hose directed by hand would give best returns from this spraying.

PICKING WORMY BERRIES.

Professor Slingerland of the Cornell Experiment Station, New York, recommends picking the wormy grapes in August and destroying them. He found that it cost only about $2 per acre to do this work and regards it as a very sure and efficient remedy.

BAGGING THE CLUSTERS.

As soon as the grapes are set they may be protected by enclosing the clusters in paper bags. This not only keeps out the grapeberry worm but also the rosebug and many fungous diseases. This method can be used where only a few grapes are raised for home use, and possibly on a larger scale for the production of basket grapes.

a *b* *c* *d* *e* *f*

Uninfested and infested grapes obtained under the different methods of treatment on North Bass Island. Baskets were filled with clusters taken at random from the plots treated by single machine double machine, and hand applications and the results with Disparene and Paris green are combined in the illustrations.

a: Uninfested grapes separated from a basket each of Disparene treated and Paris green treated plots, by single machine applications.

b: Infested grapes from *a*, therefore with identical treatment.

c: Uninfested grapes separated from a basket each of Disparene treated and Paris green treated plots, double machine applications.

d: Infested grapes separated from *c*, some treatment.

e: Uninfested grapes, separated from a basket each of Disparene treated and Paris green treated plots, hand applications.

f: Infested grapes, separated from *e*, same treatment.

INVESTIGATION TO CONTINUE.

We expect to continue our investigations with this insect for another year and merely offer this as a preliminary report. We shall be pleased to hear from the grape-growers, next season, especially as to experience, whether good or bad, obtained by following our recommendations. Our special thanks are due to the owners of the vineyards before named in which we did our spraying the past season.